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ABSTRACT

A promising recent development in tertiary education involves the application of problem-based learning as a curricular vehicle to develop student talent. Problem-based learning (PBL) is common in professional education, such as in medical, law, and business schools, and is becoming increasingly common in pre-college education. However, it is less common in information systems education. The authors have successfully applied PBL to information systems courses, and this paper reports the results. There is a major difficulty in applying PBL as there is no formal methodology of assessing students' work. This paper explores this issue by creating an instrument for assessment in a PBL setting. The instrument has been specifically designed to evaluate the generic abilities and skills of information systems graduates. It is recommended that the instrument or a modified version of the instrument be used for assessing other subject areas when the PBL is applied. The instrument has been proved to be a successful tool for assessment of the PBL. The result of applying this assessment instrument to information systems courses is also presented. An appendix presents an outline of course objectives. Includes one table. (Contains 18 references.) (Author)

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PROBLEM-BASED LEARNING ASSESSMENT FOR INFORMATION SYSTEMS COURSES

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ABSTRACT

A promising recent development in tertiary education involves the application of problem-based learning as a curricular vehicle to develop student talent. Problem-based learning (PBL) is common in professional education, such as in medical, law, and business schools, and is becoming increasingly common in pre-college education. However, it is less common in information systems education. We have successfully applied PBL to information systems courses, and are reporting our results in this paper. Moreover, there is a major difficulty in applying PBL as there is no formal methodology of assessing students' work. This paper explores this issue by creating an instrument for assessment in a PBL setting. The instrument has been specifically designed to evaluate the generic abilities and skills of information systems graduates. We also recommend that the instrument or a modified version of the instrument be used for assessing other subject areas when the PBL is applied. The instrument has been proved to be a successful tool for assessment of the PBL. The result of applying this assessment instrument to our information systems courses will also be presented.

INTRODUCTION

Problem-based learning (PBL) is an educational strategy that uses problems as the starting point for student learning (Bligh, 1995). It is a curriculum design and teaching/learning strategy, which recognizes the need to develop problem-solving skills as well as the necessity of helping students to acquire the necessary knowledge and skills (Boud & Feletti, 1997; Biggs 1999). The main issue is to reduce direct instruction as students assume greater responsibility for their own learning. Students are given ill-structured problems through which they develop high-order thinking and problem-solving skills. The shift in the teaching and learning process is more student-centered than teacher-centered. The role of the teacher is to encourage student participation, provide guidance to students, offer timely feedback, and assume the role of learner as well (Aspy et al., 1993). Evidence of the success of problem-based learning as an instructional strategy is strongly positive, particularly in fostering increased knowledge retention (Norman & Schmidt, 1992), encouraging general problem-solving skills, for deep-biased students (Norman & Schmidt, 1992; Lai, Tiwari & Tse, 1997), promoting self-directed learning skills, and increasing intrinsic interest in the subject matter. Since its introduction as an instructional method used in the medical school at McMaster University in Ontario in the 1960s, PBL has spread to numerous educational institutions around the world. To the best of our knowledge, the PBL strategy has not become so popular in the field of computer science and information systems. We have applied the methodology for the first time in our respective institutions quite successfully. The course that we applied it in our discipline was Systems Analysis. Students had to take greater responsibility for coming up with a solution for

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a given problem case. The details of this application follow this section.

Aligning PBL activities and subsequent student assessment often proves to be difficult for teachers, with many PBL activities followed by traditional assessment confusing students by disrupting their understanding of teacher expectations. Traditional assessment generally requires that students memorize the content of teaching materials without understanding. Once the examination is over, everything has been forgotten. Students learn to pass examinations without understanding what they should have learnt. On the other hand, if assessment requires students to solve problems, then they collect as many sample solutions of problems as they can. The key issue is to assess students so that they learn what we want them to learn. Quite a few PBL assessment models have been adopted, but they may not be appropriate to assess the generic quality of IS graduates. In the remainder of this paper, we describe some of the most recent PBL assessment strategies that have been adopted by different scholars, present an instrument which is particularly designed for the assessment of IS subjects when the PBL approach to teaching is applied, and finally our experience of applying this assessment instrument to IS courses in the fall of 1999. The main focus of this paper was the development and implementation of an assessment instrument when the PBL strategy is applied.

PBL ASSESSMENT MODELS

The study of problem-based learning assessment has been taken in two different directions by researchers, namely assessing the value of a problem-based learning curriculum, and student assessment in a problem-based learning approach. In this work we are concerned with the latter issue that is how to assess students' work. When we first applied PBL to our information systems courses, the first problem that we encountered was how to assess students' work in a PBL setting. Many instructors and researchers who apply or study the assessment of PBL have concerns about these issues. For example, Woods (1996) asks, "how do we handle tests in the context of small group, self-directed, self-assessment PBL?" There is, however, no general and systematic answer to this question, because students may be working alone, or in teams, and doing work that doesn't fit into readily assessable products. Researchers have been working on PBL assessment for many years and have taken different approaches. These diverse approaches in PBL assessment as pointed out by Sundberg (1999) are due to different factors that will impact on the success of student-active innovation. These include the culture of the institution, the department, or even a particular subject. Reis and Renzilli (1991) claim that the major weakness of historical and contemporary PBL efforts is the lack of formal student evaluation. In the literature, there are many studies of PBL assessment in different subject areas. Generally speaking, they all share the same concern. However, the approaches responding to these concerns differ from subject to subject and from institution to institution. In the following we present some of the most recent research results.

Nowak and Plucker (1999) provide suggestions for aligning instructional activities and assessment in the PBL process. This suggestion assumes three categories of students. In the first option, the assumption is that students are professional in the subject area of the instruction, and the instructor is their supervisor. The second suggestion is that the PBL assessment should be structured in the area of the student outcome. They provide reasonable guidelines regarding the instructor's expectation from the students. Finally, the third suggestion states that instructors should hold off an assessment until the end of the activity or until the unit of work is complete.

In the mental measurements yearbook, Buros (1999) has compiled several instruments that can be used for PBL assessment. Many faculty of McMaster University have adopted a modified version of these instruments. Some of these instruments include testing of subject knowledge, problem-solving skills, metacognitive skills, lifetime learning skills, and critical thinking skills.

Hicks (1998) classifies assessment of a PBL subject into four categories, namely teacher observation, student-produced written material and products, peer and self-evaluation, and feedback from the outside community. All of these four different classifications have the same outcome objectives, such as basic skills, and critical thinking skills. Hicks points out that the hardest to assess are the attributes and disposition of students, such as empowerment, diligence, empathy and pride.

Woods (1998) has proposed several units of skills for assessment of chemical engineering courses at McMaster University. These units focus on individuals solving relatively well-defined problems, interpersonal skills and group problem-solving, and messy problem-solving

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skills. Woods (1996) has also provided a general guideline for PBL assessment directed mostly towards chemical engineering courses.

The SOLO taxonomy (Boulton-Lewis, 1998) is based on the study of outcomes in a variety of academic content areas. It stands for Structure of the Observed Learning Outcome. It has five levels of taxonomy: prestructural, unistructural, multistructual, relational and extended abstract. It is intended to measure the students' quantitative and qualitative increase in understanding of the subject. In quantitative terms, it measures how much students can memorize and recognize terminology and a disorganized set of items. It also measures the students' performance in qualitative terms. That is how students relate, apply, generate, reflect and theorize of the subject taught. At this level, students are able to apply theory to practice for problem-solving.

Assessment by portfolio (Gibbs, 1998) requires the student to be acquainted with the course objectives and is asked to provide evidence that learning relevant to those objectives has been achieved. This requires the learner to recognize the nature and quality of his or her own learning. The student presents his or her best 'learning' against the objectives. Students have to use their judgments in assessing their own work. There are two drawbacks. First, the students may claim something, which he or she did not do. Second, the portfolio may require that students work excessively and create work both for themselves and for the teachers.

Triple jump (Feletti, 1997) uses a three-step exercise, with the student evaluated at each step: step one deals with the problem case; diagnosing, hypothesizing, checking with the database, use of information, reformulating. Step two tests them on independent study: knowledge gained, level of understanding, evaluation of information gained. Step three is concerned with final problem formulation: synthesis of key concepts, application to problem, self-monitoring, response to feedback.

Researchers at the University of Wisconsin (Stone, 1996) have adopted a new PBL assessment that they call ability-based assessment, in which they have identified nine generic abilities that a medical graduate should pass to be admitted into residency training. These abilities include appraisal, analysis, assessing own and peer performance, self-directed learning, handling stress, completing tasks, communications, consideration of professional ethics in decision-making, and interpersonal skills. Multiple-choice testing has been replaced by this activity-based assessment.

(Trevitt C. and Pettigrove M., 1995) have been using a combination of assessment and self-assessment to a fire science and management course using five criteria, namely class tests, oral debrief exercises, district committee fire management plan proposal, take home assignments and presentation. The main goal of their work is to increase the emphasis on inducing students into the process of self-evaluation according to specified criteria.

The above PBL assessment strategies have been designed for specific objectives and for specific disciplines. To the best of the authors' knowledge, no PBL assessment tool has been developed for information systems courses. When we first applied PBL teaching strategy to our courses the assessment of students' work was a major concern for both students and instructors. Students were concerned how their work would be graded and instructors were also concerned because there were no formal test or quizzes. To make the application of PBL strategy to our courses more practical and successful we have developed an assessment instrument for information systems courses that we have applied to our courses. The details of how the instrument was developed and subsequently applied are given below.

PBL ASSESSMENT INSTRUMENT

Information systems graduates (specially systems analysts) must have certain skills and ability and be prepared for industry. There is little doubt that information systems graduates should be able to

- work independently and in a group environment,
- solve a problem logically and systematically, with little or no supervision,
- understand how to acquire knowledge for problem-solving,
- have critical thinking and problem-solving ability, and
- communicates effectively (both orally and in writing)

Students must be equipped with the academic knowledge and the practical skills for problem-solving. They must understand how the theory is applied to practice, and know the circumstances necessary for achieving the cost-effective solution. There are several issues that concern

a teacher: first, what the students need to know academically; second, the skills they need to have; third, how they apply their skills and academic knowledge to know effectively when and why it is appropriate to do these things? The third should be an alignment between the curriculum objectives and assessment. That is to say, how well students know the subject, how well they have learnt, and at what level.

PBL activities support the development of 'preferred IS graduates', which also leads to long-life learners. When the PBL approach is adopted, there is some concern about how students are to be assessed with a practical and manageable assessment mechanism. The assessment of students should be aligned with their generic abilities. The assessment techniques mentioned above have targeted specific subject areas that are not necessarily suitable for IS courses. Thus, based on the previous work done by other researchers, we have created an assessment instrument specifically for IS courses. The instrument consists of a list of nine criterion skills, listed in Table 1. For each criterion skill, we have proposed a set of tasks that must be fulfilled to develop the given criterion skill. These tasks are listed immediately following Table 1. An instructor can use some or all of these tasks to assess students' work for that skill. The authors used this instrument in their information systems courses in the fall of 1999. The outcome of this experiment follows the list of criterion skills. Although the focus was on IS courses, most of these criteria can be used for other subject areas as well.

Table 1 shows the criteria that have been developed and used by the authors to assess students' work in information systems courses. For each criterion skill, we have developed a set of tasks that can be used for assessment. The details of these tasks are listed in Appendix A.

APPLICATION OF PBL AND ASSESSMENT INSTRUMENT

The authors have taught systems analysis and design for a number of years using the traditional approach. This subject is taught at the upper level of a computer science (CS) and IS program. In an effort to develop students' talents and enhance their learning, the authors decided to apply the PBL strategy to the teaching of this course in their respective institutions for the first time in the fall of 1999. The application of PBL was done with close coordination and communication between the authors.

The systems analysis course in which we chose to apply PBL is offered once a year. The course meets three times a week, two of which are lectures and the third meeting is lab/tutorial. The course was designed to be project-oriented, that is there was no formal test or quizzes, but all course requirements were fulfilled through projects. Every week there were two hours of lecture and one hour of lab/tutorial. Students worked in groups of up to six. They were assigned several ill-structured problem cases during the semester. For each problem case, students worked together to come up with a solution. During the lab/tutorial hour, the students worked on a certain aspect of their project that required group meeting, such as dividing the work among themselves, and setting future meeting dates. The instructor took the role of a coach monitoring their work.

Students were assigned several ill-structured problem cases. For each problem case, they were required to submit both individual and group work in the form of

TABLE 1
LIST OF CRITERION SKILLS FOR PBL ASSESSMENT

No	Criterion Skills	Description
1	Problem understanding	Evidence of problem understanding and independent study
2	Use of resources	Evidence of determination & utilization of information resources
3	Teamwork	Evaluation of student's teamwork success
4	Critical thinking	Evidence of practical and optimal solution
5	Management skills	Setting deadlines; finishing on time
6	Writing skills	How well and professionally the work is written
7	Oral presentation	How presentation is done
8	Team communication	How well the student communicates with team members
9	Self-assessment	Seriousness and accuracy of self-assessment

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log their projects solutions as well as their projects. The assessment instrument have been used to grade students' work. Each question in our assessment instrument were given a weight from 5 to 1 with 5 being the highest score and 1 being the lowest. This grading scale was used to grade their project work.

In the early stage of the PBL approach introduction, the change of students' attitude towards the subject and especially towards the learning process became obvious. Students found the learning activities, such as teamwork, critical thinking, and problem-solving more meaningful than the traditional approach of lecturing and taking multiple choice or short answer tests. Nevertheless, the students' main concern was assessment. Questions like, "How will you grade our work?" were raised frequently. Application of assessment instrument reduced student's anxiety significantly. This task could only be taken care of so quickly through the coordination and communication of the authors. After their first project, they developed more faith in our assessment methodology and were convinced that the assessment was relatively fair and accurate. For their subsequent projects, they showed less anxiety about their grade and focused on their learning activities. Students spent more time studying and preparing their projects in the PBL approach than in the traditional approach. The major focus of this course was the development and application of assessment instruments in PBL. The learning outcome has been very positive, and the informal feedback of students was favorable. Here are some quotes from students in our courses " I learned systems analysis topics without much memorizing", " I enjoyed working in a team", "PBL requires hard work and is a new learning experience", and "The course was challenging and fun". It is planned to have a formal survey on the students' perception of our adopted assessment instruction, the result of which will be presented in another paper.

CONCLUSION

We have successfully applied the PBL strategy to IS courses and it was an exciting experience for both students and instructors. It proved to be superior to the traditional approach to teaching in many ways. First, students' learning activities, including reading, searching, and writing, were much higher than when traditional teaching was applied to the same course. Second, the level of interaction among students was much higher. Third, the students had to keep a portfolio of their learning activities, which assisted them to be in control of the topics to be learnt. The major concern among educators who apply the PBL strategy is assessment of students' work. Evaluation of student achievement is an important aspect of education, and the skills required for solving real-world problems must be included in that assessment. In addition, alignment of instruction and assessment is essential when the PBL approach is to be used. In response to this important concern, we have developed and applied an assessment instrument that is targeted towards the generic skills of IS graduates. The assessment instrument has created a unified framework for the instructors to evaluate students' work; otherwise the assessment would have been very difficult. It has proved to be successful in many ways. It has significantly reduced students' anxiety with regard to the accuracy and methodology of assessment as they realize the need to work towards the generic abilities of IS professionals. The instructors had a better ground for evaluation with a checklist that is easy to use for those who wish to apply the PBL strategy in their courses. Although IS graduate skills are the target of our instruments, it can also be fully or partially used for assessment of other subject areas. We have provided a useful tool for instructors who plan to apply PBL in their courses

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APPENDIX A

1. **Problem Understanding Objective**:

   Students should be able to:
   - Describe all the aspects of the problem
   - Have a good idea of what needs to be done to solve the problem
   - Have created strategies to solve the problem
   - Have demonstrated the ability to work with limited supervision

2. **Use of Resources Objective**:

   Students should be able to:
   - Prepare a printed copy of the needed material for his/her reading
   - Demonstrate his/her attempt to create other resources
   - Provide an accurate summary of the search work
   - Demonstrate evidence of electronic search
   - Relate the prepared information to the given problem
   - Evaluate the accuracy and credibility of the searched information
   - Create a relation between the prepared information and the real world problem

3. **Teamwork Objective**:

   Students should be able to:
   - Demonstrate effective communication
   - Contribute at least his/her share of the work
   - Cope with conflicts
   - Evaluate team members' work fairly and honestly
   - Share information with team members
   - Demonstrate leadership ability
   - Initiate discussion
   - Help other team members when they are in difficulty

4. **Critical Thinking Objective**:

   Students should be able to:
   - Propose solutions to the given problem
   - Test their proposed solution
   - Propose alternate solutions
   - Provide reasons or justify the solutions
   - Present some background that support the solution
   - Evaluate and commend his/her solutions and the work of others
   - Present ideas/comments that are useful and constructive

5. **Project Management Objectives**:

   Students should:
   - Have a good plan, schedule, and means of controlling the project
   - Be able to arrange tasks logically and systematically
   - Estimate resources reasonably
   - Submit their work on time
   - Provide a log of all meetings and communications with other team members

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- Provide documented evidence of good communication with team members and outside organizations
- Present a record of their submitted work

6. **Writing Objective**:

Students should:
- Produce a professional report
- Provide a good introduction and summary to their report
- Perform a good problem analysis
- Produce a report with good content
- Provide alternative solutions with justification
- Draw a reasonable conclusion
- Provide references in their report
- Demonstrate the ability to convert information into a meaningful report
- Demonstrate any potential prospect for being successful systems analysts

7. **Oral Presentation Objective**:

Students must:
- Explain their work clearly
- Present the essential points of their work clearly
- Use effective visual aids to support the presentation
- Be able to answer questions during presentation
- Be able to behave professionally during presentation
- Be able to paraphrase their understanding of the topic during presentation
- Be able to transfer their knowledge to the students in an appropriate way

8. **Team Communication Objective**:

Students must:
- Have a good understanding of other team members' suggestions and points
- Demonstrate evidence of useful and constructive discussion
- Make suggestions that provide guidelines to the team
- Support their points through discussion
- Provide evidence of making constructive suggestions
- Provide concise and short messages and yet be able to resolve problems

9. **Self-Assessment Objective**:

Students should provide:
- A list of what he/she contributed
- A list of important topics learnt
- A list of accurate assessment of other team members
- A list of what he/she did not learn
- A list of the meetings he/she did not take part in
- A list of items that other students have done on his/her behalf

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